Demonstrations of Electronic Pattern Switching and 10x Pattern Demagnification in a Maskless Micro-Ion Beam Reduction Lithography System*

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A proof-of-principle ion projection lithography (IPL) system called Maskless Micro-ion-beam Reduction Lithography (MMRL) has been developed and tested at the Lawrence Berkeley National Laboratory (LBNL) for future integrated circuits (ICs) manufacturing and thin film media patterning [1]. This MMRL system (Fig.1) is aimed at completely eliminating the first stage of the conventional IPL system [2] that contains the complicated beam optics design in front of the stencil mask and the mask itself. It consists of a multicusp RF plasma generator, a multi-beamlet pattern generator, and an all-electrostatic ion optical column.

Figure 2 shows that the RF-driven ion source is capable of generating almost pure H^+ ions from a uniform plasma region with a diameter of nearly 20 cm. The pattern generator, consisting of an array of micro-apertures, is patterned on two (plasma and extraction) electrodes separated by a ~5-μm layer of insulating material. Individual ion beamlets can be switched on or off to form the lithographic pattern by biasing the extraction electrode with respect to the plasma electrode. Removing the use of stencil masks from the lithographic process via such an electronic pattern would result in enormous cost savings by eliminating the technology efforts for mask development, defect detection, and defect correction. The use of an electronic pattern would also offer improved flexibility for rapid implementation of new designs and higher throughputs due to time savings from the elimination of multiple mask steps. The ion optics has been characterized for a prototype MMRL system via the MUNRO computational codes [3].

Results from ion beam exposures on PMMA and Shipley UVII-HS resists using 75 keV H+ are presented in this paper. Figure 3 shows exposures rendering sub-micron features on PMMA resist. These results have confirmed the 10x demagnification optics of the MMRL system and demonstrated exposures by a pulsed plasma. Two different beam switching schemes have been employed to control the exposure time--thus the exposure dose: one using a pulsed plasma and the other using a biased pattern electrode. Micro-ion beam extraction and switching through a multi-layer (conductor-insulator-conductor) array of nine 50-μm apertures has already been reported [4]. Proof-of-principle electronic pattern switching together with reduction ion optics (Fig. 4) (using a pattern generator made of nine 50-μm switchable apertures) has been performed and is reported in this paper. In addition, fabrication issues and exposure results of a micro-fabricated pattern generator [5] on an SOI membrane are presented. Finally, this paper also presents a comparative analysis between the aberrations predicted by computational optics simulation and those resulted from experimental measurements.

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* This work is supported by DARPA and the US Department of Energy under contract number DE-AC03-76SF00099.
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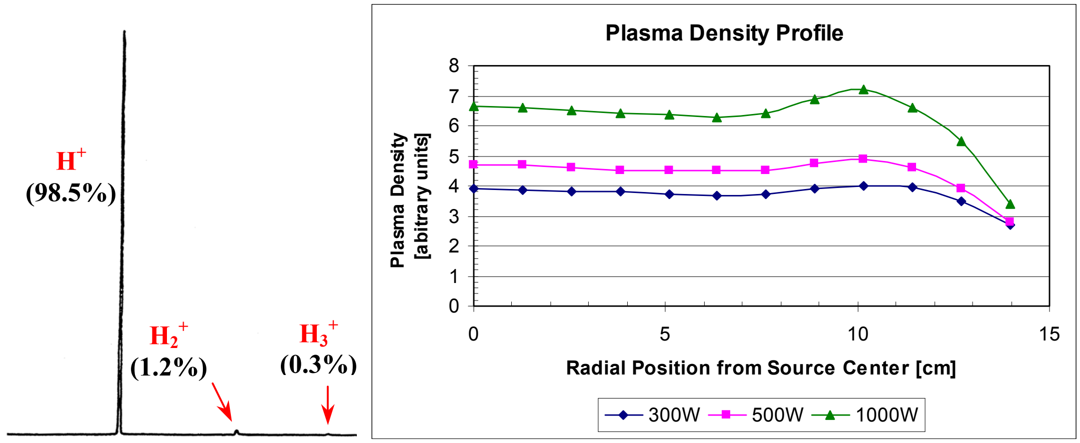

Figure 2. MMRL ion source characterization: (left) Hydrogen species spectrum (RF Power = 2500 W, Pressure = 5 mTorr); (right) Radial plamas density profile.

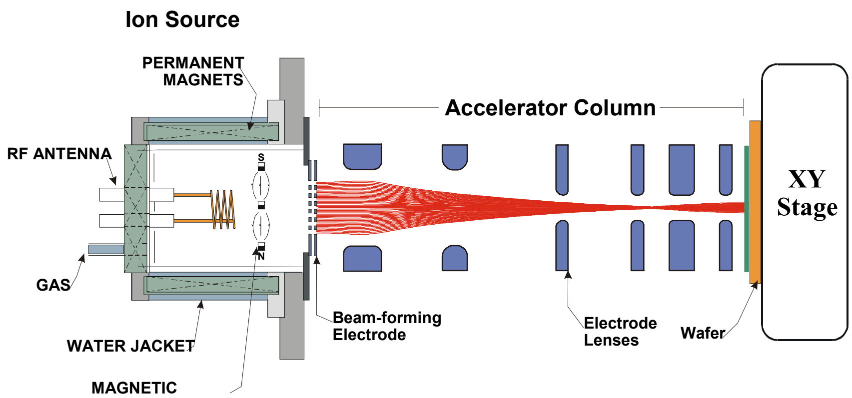

Figure 1. the proposed Maskless Micro-Beam Reduction Lithography system using a universal pattern generator to form the lithographic pattern.

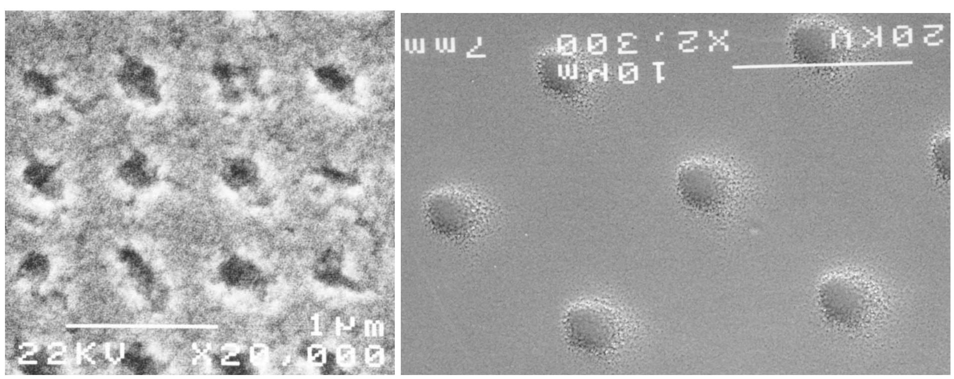

Figure 3. 160 nm features at 566 nm pitch in PMMA (left). 10 μm pitch holes in PMMA(right).

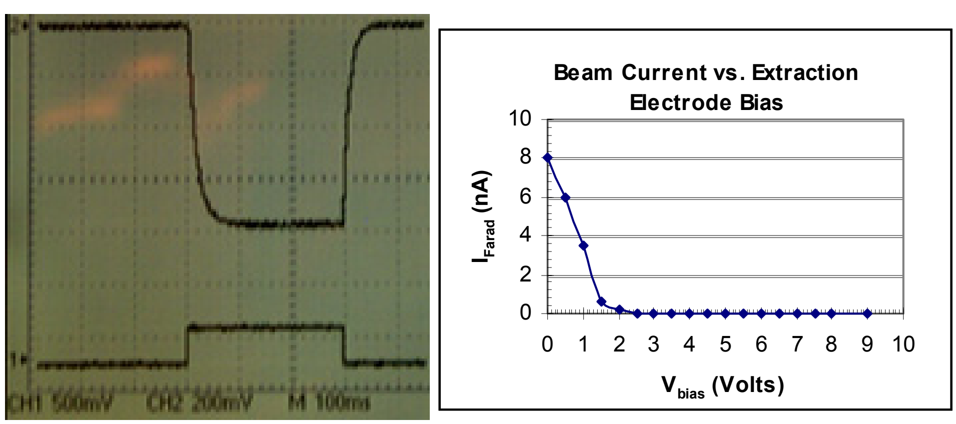

Figure 4. 300 ms pulse current (8nA--left) profiles extracted from an electronic switchable pattern.